

# Fault-controlled Zinc Mineralization in the Antigonish Highlands, Antigonish and Pictou Counties, Nova Scotia

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Open File Report ME 2001-1

## Introduction

A little known and under-explored style of fault-controlled Zn mineralization occurs in the Antigonish Highlands (Fig. 1) of Nova Scotia. Examples of this mineralization style have been found in two areas: at Georgeville in the northeastern portion of the highlands, and at Kirkmount in the southwest.

At Georgeville, sphalerite occurrences at several

sites have undergone one period of mineral exploration (between 1967 and 1970) and one subsequent examination in 1976. These exploration efforts, which were actually a search first for Cu then for Pb, recognized the presence of thick intersections of low grade, structurally controlled sphalerite in late Precambrian units of the Georgeville Group (formerly called the Greendale Group). No further exploration of the occurrences at Georgeville has been documented since 1976.

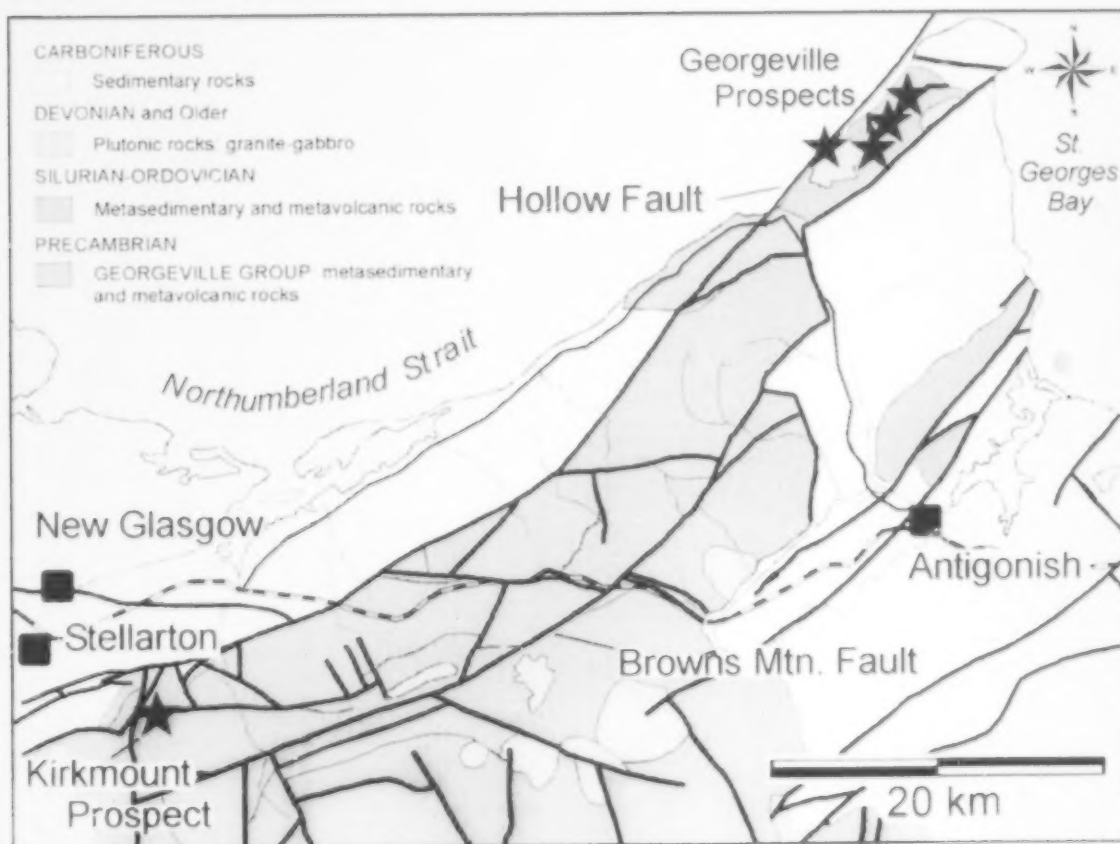


Figure 1. Generalized geology of the Antigonish Highlands showing the location of fault-controlled Zn prospects and major fault structures.

The Kirkmount prospect consists of veins and fracture-fillings of carbonate and the zinc silicate willemite ( $\text{Zn}_2\text{SiO}_4$ ) in fractured and brecciated metasilstone. These country rocks belong to the same late Precambrian Georgeville Group as are present at the Georgeville prospects.

The Kirkmount prospect was discovered by St. Joseph Explorations Limited in 1980 as a result of follow-up work on Zn anomalies defined in a Nova Scotia Department of Mines stream sediment geochemical survey from 1977.

There is a basic mineralogical difference in the principle Zn-bearing mineral phase at the two sites: sphalerite at Georgeville and willemite at Kirkmount. However, it is important to note that the same late Precambrian rock units underlie both areas. As well, the Zn minerals at both sites occur with a strong fracture control and these fractures are the result of movements on the same series of regional scale, northeast-trending faults.

## **Geological Background**

### ***Antigonish Highlands***

The Antigonish Highlands consist of a peneplained, highland massif of late Precambrian and lower Paleozoic "basement rocks", surrounded by lowland areas underlain by Carboniferous continental and marine sedimentary rocks and evaporites. The backbone of the Antigonish Highlands is the early Hadrynian Georgeville Group (Fig. 1), which is a conformable mix of metavolcanic and metasedimentary units. In the Georgeville area (Fig. 2), the Georgeville Group is represented by the Chisholm Brook Formation and conformably overlying Morar Brook Formation. The Chisholm Brook Formation contains the oldest rocks known in the Antigonish Highlands, and consists predominantly of mafic flows, tuffs, pyroclastic units and marble. Mafic dykes are spatially associated with the volcanics.

The Chisholm Brook Formation grades conformably upward over a 20 m interval into the Morar Brook Formation. The Morar Brook Formation is a sequence of poorly cleaved, laminated, black-greenish metasilstones. Thin interbeds of marble and chert also occur and, in places, the metasilstone is mildly calcareous.

The area around Kirkmount is also underlain by rocks belonging to the Georgeville Group. Metasilstone, metawacke and minor metavolcanics of the James River Formation underlie the prospect. The James River Formation is believed to be a lateral equivalent of the Morar Brook Formation.

### ***Plutonic Rocks***

All of the Georgeville Group rocks are intruded by plutons of late Precambrian gabbro-diorite and Devonian-Carboniferous intermediate-felsic granitoids. The gabbroic plutons may have metallogenic significance, especially with respect to the Georgeville prospects, as they appear to have a spatial association with both the Zn occurrences and regional scale faults that traverse the area (see below). In addition, the frequency and magnitude of the Zn mineralization increases appreciably in proximity to the plutons.

### ***Cobequid-Chedabucto Fault Zone***

Particular metallogenetic significance lies in the fact that the Antigonish Highlands and surrounding Carboniferous sedimentary rocks are deformed and cross-cut by several regional scale, northeast-trending fault structures. These faults are related splay faults to the major east-west Cobequid-Chedabucto Fault Zone (CCFZ), which essentially cuts Nova Scotia in half and is the province's most prominent structural feature.

Most workers feel the CCFZ originated as a result of dextral-sensed, strike-slip movement



**Figure 2.** Geology of the Georgeville area showing the location of Zn prospects.

resulting from collision of North America with North Africa(?) starting in the early Devonian. However, in the Antigonish Highlands there is strong evidence suggesting formation and movements on the Hollow and Browns Mountain faults (Fig. 1) took place as far back as the late Precambrian, and that the faults were

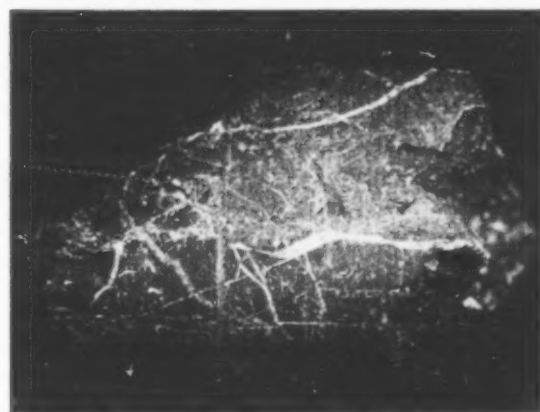


**Figure 3** Diamond-drillcore sample (BQ) of typical Morar Formation metasiltstone showing fracture-controlled sphalerite-carbonate veins

subsequently re-activated during the Devonian Acadian Orogeny. This is supported by features within the Zn occurrences that display an obvious structural control, coupled with a spatial association with the late Precambrian gabbroic

plutons. Clearly, however, a lot of additional work is necessary to better understand these features.

## Exploration History

### Georgeville Zn Prospects

Bridger (1953) first recognized Cu and Zn occurrences in the Georgeville area, and reported the presence of rusty, pyritiferous zones in fractured argillite outcrops along the highway and seashore. He made the observation that they occurred close to the diorite (gabbro) intrusions found in the area. His main interest was Cu, but he found chalcopyrite to be "very sparse" and that sphalerite was more abundant.

Between 1954 and the mid-1960s there was further exploration of the property, consisting of geochemical surveys, geophysical (self potential) surveys and prospecting. These efforts revealed widespread geochemical anomalies on several of the brooks draining the property and coincident geophysical anomalies. All of this interested New Jersey Zinc Exploration Company Limited such that they embarked on a concerted exploration effort in 1967. MacLeod (1967) reported that geochemical soil and stream silt surveys defined five main areas of interest, mostly based on elevated Zn response of a magnitude greater than 1000 ppm. He drew the following conclusion "Collectively the various soil anomalies indicate the possibility of widespread Zn mineralization associated with the diorite-metasediment contact and an undetermined regional geological structure trending northeast."

In the latter part of 1968 and early 1969, New Jersey Zinc drilled five diamond-drill holes in the area of Morar Brook (called McPherson Brook in their reports) along a northeast-trending coincident series of geochemical and geophysical anomalies (Bartlett, 1969). During the previous summer, low grade sphalerite was noted on

outcrops along that section of the brook. Low grade Zn was encountered in four of the drillholes in the form of light- to dark-brown sphalerite occurring in small veinlets and along hairline fractures in the metasiltstone host rock (Fig. 3). The fracture control of the mineralization and close association with carbonate veins were noted. Table 1 summarizes the drilling and assay results.

**Table 1.** Diamond-drill results for the 1968 Morar Brook drilling at Georgeville.

| DDH     | Core Length<br>(ft.) | Av. % Zn |
|---------|----------------------|----------|
| 1-GD-68 | 17.2                 | 0.5      |
|         | 172.2                | 0.47     |
|         | 210                  | 0.43     |
| 2-GD-68 | 54.4                 | 0.45     |
|         | 11.5                 | 0.68     |
|         | 24.2                 | 0.57     |
|         | 12.7                 | 0.49     |
|         | 100.0                | 0.39     |
| 3-GD-68 | 10.0                 | 0.60     |
|         | 6.5                  | 1.30     |
|         | 15.0                 | 0.52     |
| 4-GD-68 | 55.0                 | 1.00     |
|         | 55.0                 | 0.80     |
|         | 170.0                | 0.69     |

Exploration continued the following year with three more holes drilled in two areas a few kilometres to the southwest of the Morar Brook drillholes (Cunningham, 1970; Fig. 2). Diamond-drill hole 6-GD-70 intersected a mixed sequence of metasiltstone and metavolcanics, and DDH 8-GD-70 intersected a section of highly altered diorite intruding metasiltstone. Sphalerite is present in all three drill cores with extensive, but low grade, intersections. DDH 6-GD-70 intersected 40' of 0.93% Zn; DDH 8-GD-70

intersected 50' of 0.53% and two 25' sections of 0.43% and 0.65% Zn, respectively; and DDH 9-GD-70 intersected 204' of 0.32% Zn.

Although a recommendation was made to continue exploration in the area, there is no further report of work done by New Jersey Zinc. It is generally held that their main interest was in discovering Cu deposits and that they considered the magnitude of the Zn intersections to be too low grade.

The area remained inactive until 1976 when Noranda Exploration Company Limited carried out a two hole diamond-drill program as part of an option agreement with Gold Brook Developments Limited (Johnson, 1976 and Graham, 1977). One hole was in the vicinity of New Jersey Zinc's DDH 6-GD-70 and encountered similar geology and mineral occurrences. The other tested a geophysical and geochemical anomaly originally slated for drilling by New Jersey Zinc that was not drilled due to a landowner dispute. This hole intersected fracture-controlled sphalerite in mixed metasiltstone and metavolcanics intruded by altered diorite. No assays were reported from either hole. Since 1977 there has been no further reported exploration in the Georgeville area.

### **Kirkmount Zn Prospect**

St. Joseph Explorations Ltd. (subsequently Sulpetro) discovered Zn in the Kirkmount area in 1979-80 (Sangster, 1980; Fig. 1). Their exploration commenced with geochemical and geophysical surveys, and defined an area of widespread soil anomalies for Zn (up 6500 ppm). Two diamond-drill holes were drilled, one of which (DDH 326-2) encountered a sequence of fractured and brecciated meta-siltstone with low grade, but extensive Zn (Fig. 4). The main Zn-bearing mineral was found to be the unusual and highly fluorescent Zn-silicate willemite, which occurs as veins, veinlets and fracture-fillings

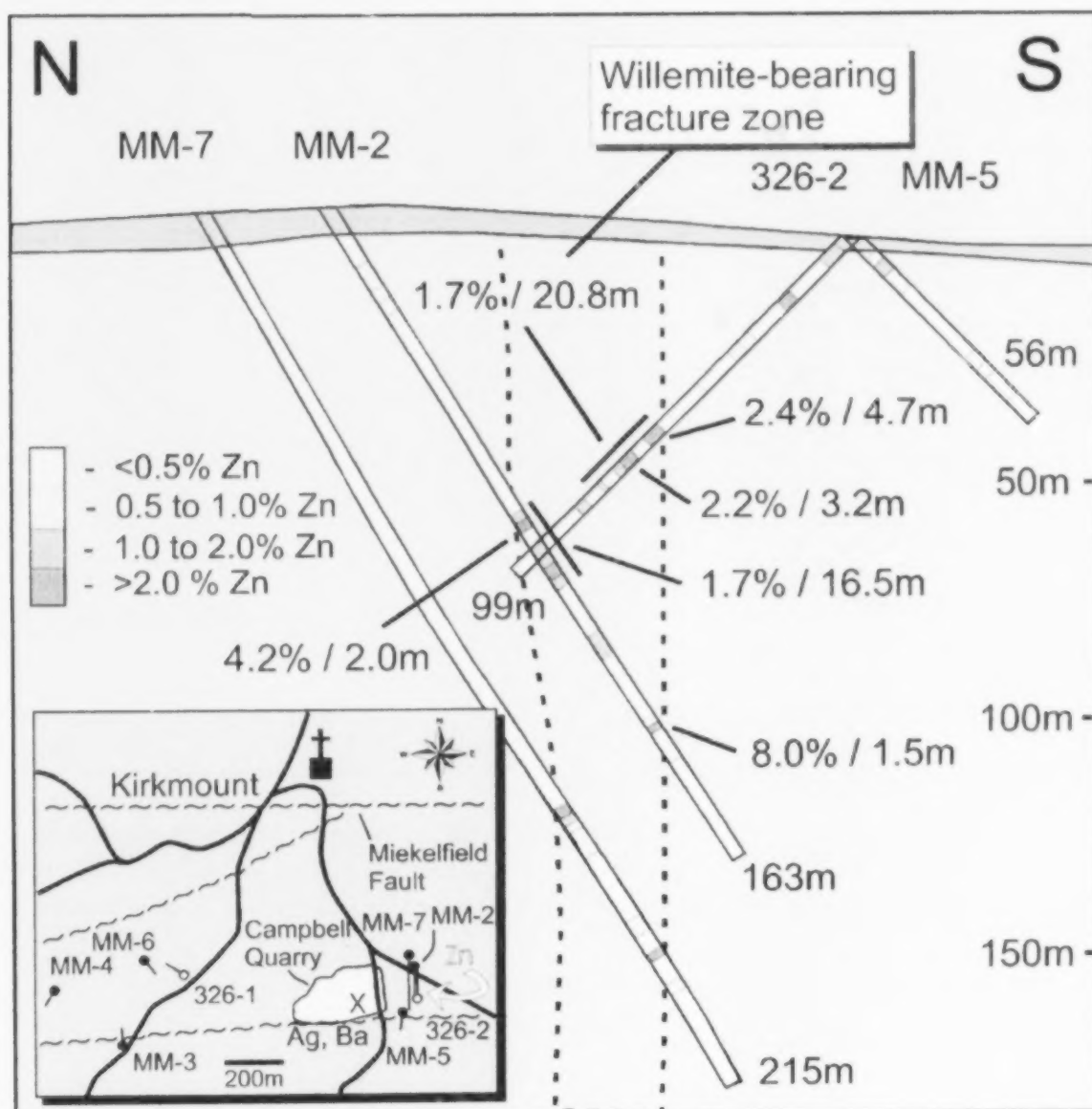


**Figure 4** Cross-sectional profile along DDH's MM-2, 5 and 7 of Falconbridge Ltd. and DDH 326-2 of St. Joseph Explorations Ltd. at the Kirkmount Zn prospect. Zinc assays (wt.%) and intersection intervals are from Sangster (1980) and Mallinson (1988).

(Sangster, 1980, 1986, Fig 5) Sangster (1980) reported assays in the order of 1.66% Zn over 20.8 m. Several assays of the mineralized intersections are shown on Figure 4.

Although willemite is apparently the dominant Zn-bearing mineral phase, fine-grained sphalerite

is also reported, but in much lesser amounts. It is also interesting to note that such minerals as native Ag, barite, hematite, siderite and Mn-rich carbonate also occur.

Falconbridge Ltd. continued the exploration of Kirkmount between 1986 and 1988 (Mallinson,

1988). Their work consisted of lithogeochemistry, geophysical (IP and VLF) surveys, trenching and a seven hole diamond-drill program (956 m). Three of the diamond-drill holes were positioned to provide a cross-sectional profile across the brecciated zone discovered by St. Joseph DDH 326-2 (Fig. 4). The remaining four holes tested other geochemical and geophysical targets.

The drill profile across the discovery hole verified that the willemite-bearing breccia zone continues to a vertical depth of at least 151 m. In



**Figure 5.** Core sample of fractured metasiltstone from the Kirkmount prospect. Upper photo shows sample in ordinary light while lower photo shows sample in ultra-violet light. Willemite is the fracture-controlled, brilliant greenish fluorescing mineral. Scale indicated in cm.

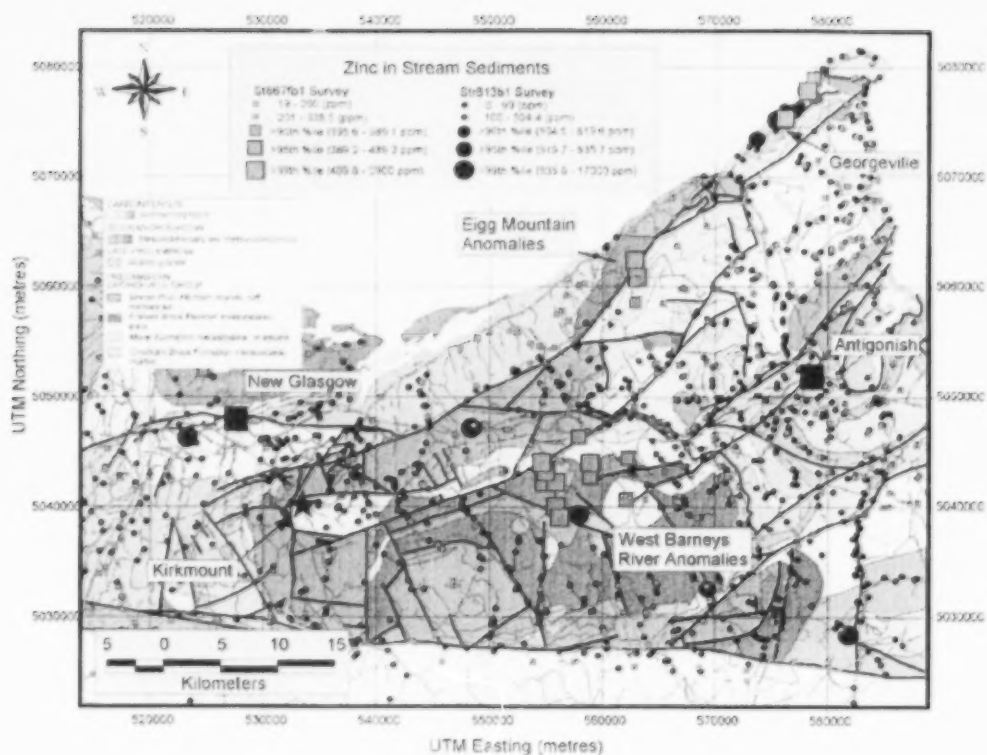
addition, Falconbridge made a firm positive correlation between the Zn and Ag mineralization, and found that fine-grained sphalerite exists in greater abundance than originally thought. However, willemite is still the main Zn-bearing mineral phase. The company concluded that an east-trending, vertically dipping, brecciated and fractured zone exists that is 32 m wide and extends to at least 151 m depth. The strike extent of the zone has not been determined,

but it parallels several regional-scale fault zones that traverse the property (Fig. 4).

Discussion of the genesis or significance of the presence of willemite is beyond the purpose of this summary, but some statements are warranted. In the literature, especially prior to 1985, willemite was generally considered a supergene mineral, the result of weathering in arid climates (Sangster, 1986). However, more recent studies of willemite deposits elsewhere (e.g. Soares Monteiro et al., 1999) have determined that willemite precipitates at temperatures between 200-300°C from highly oxidized and sulphur-poor metamorphic fluids. This is consistent with the structurally controlled style at Kirkmount and its close similarity to a host of Fe-oxide and sulphide deposits found along the Cobequid-Chedabucto Fault Zone. Whatever the origin of the willemite, supergene or hypogene, its presence at Kirkmount is an indication of a Zn source in the area.

## Zinc Geochemical Anomalies

The Nova Scotia Department of Mines and Energy (currently Department of Natural Resources) carried out two reconnaissance stream sediment geochemical surveys over the Antigonish Highlands (Fig. 6). The first, in the mid-1970s (Bingley, 1977b), attracted St. Joseph Explorations Limited to the Kirkmount area where they made their initial discovery. Data from the original Bingley (1977b) survey are available in non-digital form only from the Department of Natural Resources library in Halifax. However, in 1983 the department re-analyzed a representative selection of the samples from the Bingley (1977a, b) surveys and these data are available in digital form, free-of-charge from the DNR web site as Survey Str813b1 (<http://www.gov.ns.ca/natr/mob/pubs3.htm>). The highlands were again included in a stream sediment survey of northern Nova Scotia and western Cape Breton Island in 1986-87 (Mills, 1989). These data are also available digitally as Survey St867b1 from the same web site.



The Zn results for surveys St813b1 and St867fb1 over the Antigonish Highlands are provided in Figure 6. The results are graduated to highlight samples above the 90<sup>th</sup>, 95<sup>th</sup> and 99<sup>th</sup> percentiles. Interesting patterns are present. The Georgeville area shows a high response in both surveys but the Kirkmount area does not. It is important to note, however, that the 1983 re-analysis of samples did not include all of the samples collected during the mid-1970s surveys. Most, if not all, of the original anomalous Zn samples for Kirkmount in the Bingley (1977b) survey were not included in the St813b1 re-analysis. Furthermore, the entire Kirkmount area is only represented by one sample in the Mills (1989) St867fb1 survey. Both the Kirkmount and Georgeville areas show up as highly anomalous for Zn in the original Bingley (1977a&b) data.

Two other areas of anomalous Zn samples stand out in Figure 6: the Eigg Mountain area, farther to the southwest along the Hollow Fault from Georgeville, and the West Barneys River area in the central portion of the highlands. Like Georgeville, Eigg Mountain is adjacent to the Hollow Fault, and is underlain by the same Chisholm Brook and Morar Brook Formation country rocks. The anomalies suggest that as yet undetected fracture-controlled Zn mineralization may also be present in the Eigg Mountain area.

A large cluster of anomalous samples occupies an area near West Barneys River. Little is known of this impressive array of samples. The area is underlain by Georgeville Group rocks as is Georgeville and Kirkmount. In addition, it lies adjacent to the regional scale, Brown's Mountain Fault, a parallel splay related to the Hollow Fault. The metasediments are intruded by a series of intermediate to felsic intrusions but it is not known if these had any role to play. St. Joseph Explorations Ltd. staked this area during their exploration at Kirkmount, but did not explore the area to the same extent. According to

Sangster (personal communication, 2001), St. Joseph verified the anomalies, but the company geochemist considered the anomalies to simply represent an area of high background and that they were related to scavenging of Zn along Mn-stained fractures. The area was subsequently abandoned. It would seem more prospecting in the area is warranted.

## Summary

Fracture-controlled sphalerite occurs over a wide area of the Antigonish Highlands. There is a close association of the mineralization with fracturing resulting from movements on the regional scale, northeast-trending faults that cut the area. In addition, it appears that the metals and/or hydrothermal fluids may be associated with a series of fluid-rich gabbro/diorite intrusions that intrude the late Precambrian metasedimentary and metavolcanic host rocks.

The same late Precambrian host rocks underlie much of the Antigonish Highlands. Likewise, the northeast-trending fault structures persist throughout the highlands, as do the gabbro-diorite intrusions. Furthermore, the intermediate-felsic plutons found in the central region of the highlands are spatially associated with a cluster of high magnitude Zn in stream sediment anomalies. These anomalies have been verified in subsequent geochemical surveys, but still remain essentially unexplained. They are strongly suggestive of Zn mineralization.

Given that the sphalerite occurrences at Georgeville and Kirkmount are low grade and pervasive, they easily escape detection. Similar occurrences of this mineralization style could persist throughout the highlands in areas that have never undergone exploration of any sort.

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